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cal properties of the follicle membrane that might readily occur under ordinary conditions. These questions will be discussed in the full account of the work to be published in the *Archiv für Zellforschung*.

GROWTH AND VARIATION IN MAIZE

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The Problem. The investigation reported in this paper is an attempt to analyze the normal variation of an organism in a particular case, from the standpoint of *Entwicklungsmechanik.* It was suggested in the first instance by the study of variation and differentiation in *Ceratophyllum* made by Pearl some years ago. We have here attempted to approach the problem of *inter*-individual variation from the same point of view and with similar methods to those applied to the problem of *intra*-individual variation in the case of *Ceratophyllum.*

The problem and the point of view may be most clearly defined by considering briefly certain well-known, indeed obvious, facts about variation. If one brings together a homogeneous group of individual plants or animals and measures the same character in each individual, there may be formed from the resulting data a characteristic variation curve for that group and character. The precise form of this curve, as well as the location in it of any particular individual, are functions of two basic variables. Of these one is the hereditary or germinal constitution of the individual. The other is the complex of environmental stresses and strains, which, each acting on the individual during its ontogeny have influenced the end result of the activity of the hereditary determiners or genes.

Now it is altogether usual in discussions of variation and heredity to take the two end terms of the ontogenetic series, the gene on the one hand and the adult soma on the other hand, as things given. What comes between the two is neglected. But clearly what goes between is a part of the very essence of heredity itself.

In any group of adult individuals each one will show some particular variation, in the sense of a deviation from the typical condition of the group. We take it to be one of the final objects of investigations in genetics to find out why (in the sense of locating the essential causal factors involved) a particular individual A exhibits a particular variation a, and not some other variation out of the indefinitely large number of possibilities. By means of Mendelian modes of research considerable progress has been made towards answering this question for many kinds of qualitative variations. For fluctuating or quantitative variations also, progress has been made through the researches especially of East and his associates, following those of Nilsson-Ehle on colors determined by multiple factors.

What we have tried to do in the present investigation is, by studying the growth of the individual, to analyze the adult variation curve into its component elements. We have attempted, in other words, to make a beginning at an understanding of the developmental physiology of the genes concerned in the production of the characters studied.

A given individual, at an early stage of growth, may exhibit an exceptional condition of a character, as compared with other individuals of the same age or stage of growth. It may be, for example, very short, the shortest plant in the whole population at three weeks of age. Will this same individual be the shortest plant in the adult population, after all growth is completed? If not, where is it in the adult variation curve, and how did it get there? This example will give a concrete idea of the general mode of approach to the problem of variation followed by this paper.

Results. Measurements were made at twice-a-week intervals of the height of each individual of three series of plants of a variety of sweet corn used in other experimental work in this laboratory and described in earlier papers. The heights were measured to the tip of the tallest leaf. In addition to these, separate sets of measurements were also made of the tassel height as soon as the tassels appeared. The growth curves obtained by plotting the mean height at each measurement are relatively smooth. After July 3, the time of tasseling, the plants grow in height much faster than before. Growth in height ceases entirely as soon as the tassel blooms.

The relative variability considered for the whole season shows a marked progressive diminution. It thus follows the general growth law of diminishing variability. Considered in detail, however, the relative variability first shows an increase. After June 19 there is a rapid decrease until the time of tasseling. During the period of tasseling there is a very rapid increase in the relative variability. This is followed by an equally rapid decrease. A stable condition is finally reached which is some 10 per cent lower than the variability at the beginning of the season.

The quantitative relations of tasseling to the growth and variability of the height of corn plants are very similar to the quantitative relations of puberty to the growth of children. This does not necessarily mean that the two processes are analogous physiologically, but it is a fact of interest and worth further consideration from a physiological point of view.

It appears probable that the corn plant grows in a series of cycles. Each cycle is characterized by the special development of one set of organs. They are, in order, the root cycle, the leaf cycle, the tassel cycle, and the ear cycle.

With these general facts regarding the growth of the maize plant in hand the analysis of the variation in terms of individuals was undertaken. Individual plants and groups of plants having the same relative size at one stage of their growth, were followed as individuals through the remaining growth stages. We have endeavored to ascertain how such plants are distributed as to relative size in the successive growth stages and to discover the factors determining these distributions.

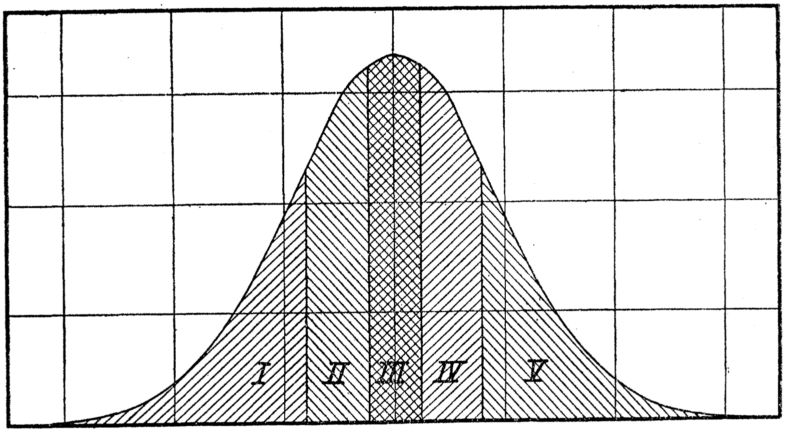

FIG. 1. DIAGRAM TO ILLUSTRATE THE DIVISION OF A FREQUENCY CURVE INTO QUINTILES. IN THIS DIAGRAM A NORMAL CURVE HAS BEEN DIVIDED INTO 5 EQUAL AREAS BY THE FOUR PERPENDICULAR SOLID LINES. THE FREQUENCY IN ANY ONE OF THESE AREAS IS EQUAL TO THAT IN ANY OTHER.

To study these questions it is necessary to have a measure of the *relative* size of the plants at each growth stage. For this, each distribution was divided into five equal areas or quintiles. In any distribution the relatively small plants are in quintile I and the relatively large ones in quintile V. Figure 1 illustrates the exact meaning of a quintile.

The problem was first approached by studying the quintile distribution of all the measurements, throughout the season, of a group of plants starting in a given quintile. It is shown that there is a strong tendency for the plants to remain in or near the quintile in which they started. As a measure of this tendency use is made of the root-mean-square deviation of these observed distributions from the most probable distriburion of such measurements on the theory of chance. The tables of these constants are too extended to be given here, but the figures show that in every case (except one) the deviation from the theoretical mean is very much greater than would occur on the basis of chance. The deviation of the very small and the very large plants (quintiles I and V) are much greater than any of the others. Thus there is a much more marked tendency for the extreme plants to remain in the extreme classes than for the medium sized plants to remain in a particular medium sized class. There is a similar, though less marked, tendency for the plants *ending* in a given quintile to have remained in or near that quintile throughout their growth.

The second step in the analysis was to study the *mean quintile position* of each group of plants in the successive growth stages. Here the main conclusion is entirely clear. Extreme variants at the beginning of the season tend strongly, on the whole, to remain extreme variants during the whole season. At the same time such extreme variants regress slightly towards the general population mean as growth continues. This second tendency is, however, by no means so strong as the first.

The third step in the analysis of the variation curves was a study of the average relative size (mean quintile position) of the individual plants and of the variability of individual plants with respect to relative size. Definite quantitative evidence is presented showing that:

1. The observed differences in the manner of growth of individual plants and of groups of plants cannot be explained as the effect of external, environmental factors.

2. These differences are rather to be looked upon as the effect of internal factors.

3. The distribution of the average relative size (mean quintile position) of individual plants is such as to suggest the random distribution of these factors among the plants. The same thing is brought out by the distribution of the relative measurements of plants starting or ending with a given relative size (quintile).

4. The simplest method of explaining these facts is to regard the differences in the manner of growth as due to independent Mendelian factors which are distributed at random in any population of open fertilized maize plants. These factors would occur in the proportions found in a stable Mendelian population mating at random.

5. By assuming the presence of two independent growth factors and weighting each with the proper value, it is possible to obtain a theoretical distribution agreeing very closely with the observed distribution.

6. The interpretation of the growth of these plants by Mendelian factors is further strongly supported by the distribution of the standard deviations of the plants with different relative sizes. Thus it has been shown that the extreme plants which would be more nearly homozygous and for this reason less variable are, as a matter of fact, some 50 per cent less variable than the plants in the middle class after all allowance has been made for the difference in the size of the means.

This is a preliminary abstract of a paper with the same title now in press in the *Zeitschrift für induktive Abstammungs- und Vererbungslehre.*

ON A NEW GROUP OF BACTERICIDAL SUBSTANCES OBTAINED FROM HEXAMETHYLENETETRAMINE

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Ever since the introduction of hexamethylenetetramine into medicine, this drug has attracted wide attention owing to its far-reaching possibilities as an internal antiseptic. In addition to its rapid appearance in the urine it is found after ingestion in practically all the body secretions, including even the cerebrospinal fluid. It is fairly well established that the antiseptic action of the drug is due to the liberation from it of formaldehyde by virtue of the acidity of the medium in which it acts, but that its diffusion throughout the body is a physical property of the undecomposed molecule. In other words, hexamethylenetetramine is but a vehicle for formaldehyde, and if the two conditions are satisfied, firstly, its appearance in large enough amount in the locality desired, and secondly, its cleavage to formaldehyde, a local internal antiseptic action might be expected. Owing, among other things, to the alkalinity of most of the body fluids the limitations set by these prerequisites are obvious.

Numerous attempts have already been made to achieve by proper chemical variation an improvement in the action of the drug. Such attempts, however, which have been confined almost entirely to combinations of hexamethylenetetramine with acids and phenolic compounds, have offered few advantages over the original drug. It seemed to us that more promising results might be obtained by a more direct variation of the hexamethylenetetramine molecule itself and a brief outline of the facts observed in the course of this work is the subject of the following:

The molecule of hexamethylenetetramine functions as a tertiary base,